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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAM OF THE

ROCHESTER MEETING

AT

THE UNIVERSITY OF ROCHESTER
ROCHESTER, NEW YORK
JUNE 22 AND 23, 1936

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The American Physical Society

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JUNE 5, 1936 Vol. 11, No. 4

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

ROCHESTER MEETING, JUNE 22–23, 1936

THE 207th regular meeting of the American Physical Society will be held at Rochester, New York on Monday and Tuesday, June 22 and 23, 1936 on the new River Campus of the University of Rochester located on River Boulevard at Elmwood Avenue. The Monday sessions will be held in the Physics Building (Bausch and Lomb Hall) and in the Geology and Biology Building (Dewey Hall) adjacent to it. The Tuesday symposium will be held in Strong Auditorium.

Symposium on Applied Physics. On Tuesday morning at 9:30 o'clock in the lower lecture room of Strong Auditorium there will be held a symposium of invited papers on *Some Problems in Applied Physics*. The speakers on this symposium will be Dr. C. E. K. Mees of the Eastman Kodak Company; Dr. Irving Langmuir of the General Electric Company; Dr. W. B. Rayton of the Bausch and Lomb Optical Company, and Dr. Frederick Seitz of the University of Rochester.

Registration. The registration desk will be in Todd Union directly opposite the dormitory building.

Accommodations. Insofar as possible visiting members of the Society will be housed in the Men's Dormitories on the River Campus. One hundred single rooms only are available with usual dormitory facilities, and both men and women will be accommodated. The dormitories will be open Sunday afternoon and may be occupied until Wednesday morning. The rate will be one dollar per person per day. **Reservations should be made at once on the Advance Registration Card, page 5.**

Breakfast and luncheon will be served in the Todd Union cafeteria on Monday and Tuesday.

Those who prefer hotel accommodations should make reservations by writing directly to the hotel, as follows:

Hotel Seneca Clinton Avenue and Main Street	$3.00 and up single.	$4.00 and up double.
Hotel Sagamore 111 East Avenue	$3.50 and up single.	$5.00 and up double.
Powers Hotel 34 West Main Street	$2.00 single.	$4.00 double.

The hotels are all in the downtown district about two and one-half miles from the River Campus. The campus can be reached by taxi (fare about fifty-five cents) or by the Plymouth Avenue bus.

Dinner. On Monday evening at 6:15 o'clock there will be a joint dinner with the Rochester section of the Optical Society of America held in Todd Union on the River Campus. The tickets will be $1.25 each and may be purchased at the registration desk until 2:00 P.M. Monday. *Advance reservation on the enclosed card is urgently requested.*

Entertainment. At 8:00 o'clock Monday evening immediately following the dinner the San Carlo Opera Company will present an open air opera "Madame Butterfly," at the University Stadium on the campus. A block of seats has been reserved for members of the Society and guests. Tickets at one dollar each may be obtained at the registration desk until 2:00 P.M. Monday. *Advance reservation on the enclosed card* will insure seats in the reserved section. On Tuesday night the same company will present "Il Trovatore" and reservations may be made at the desk for those who wish to stay for this performance. In case of rain on Monday the

admission price will be refunded and an informal reception in Todd Union will be held instead.

The officers of the Taylor Instrument Companies have invited the visiting members of the Society to a complimentary luncheon at their plant restaurant on Tuesday at 1:00 o'clock. The luncheon will be followed by a trip through the plant. Those wishing to attend should register at the desk before 2:00 P.M. Monday.

Trips through the plant and laboratories of the Eastman Kodak Company, Bausch and Lomb Optical Company, Taylor Instrument Companies (see above), and the Stromberg-Carlson Company have been arranged on Monday and Tuesday afternoons for those interested.

An informal reception and tea for the visiting ladies will be held Monday afternoon at 3:30 o'clock. A complimentary luncheon for the visiting ladies is being planned for Tuesday. This will be preceded by a drive through the city and followed by a visit to the Memorial Art Gallery.

If weather permits, a swimming party and picnic will be held on Lake Ontario on Tuesday afternoon beginning at 4:00 o'clock. Announcement of further details will be made at the meeting.

Transportation. No arrangements have been made for reduced railroad rates on the convention plan. This is due in part to the confused situation in connection with the proposed reduction of the regular rates now being considered by a number of the eastern railroads. It is advisable for all who are planning to attend the Rochester meeting to consult their local ticket agent for information regarding the possibility of summer excursion fares and other reduced rates.

American Association for the Advancement of Science. The American Association for the Advancement of Science is meeting in Rochester for a three-day session, June 16, 17, and 18, 1936. Section B of the A. A. A. S. has arranged three joint symposia, one with the Section on Geology and Geography, another with the American Meteorological Society, and a third on the subject of physiological effects of radiation. For details of this meeting see the Preliminary Announcement appearing in the Friday, May 15, 1936 issue of *Science*.

Sigma Xi Society. On Friday and Saturday, June 19 and 20, 1936 there will be held in Ithaca the celebration of the semi-centennial of the Sigma Xi Society. For further information about this program consult *Science*.

General Rules Relating to Papers

Only those titles of papers shall be listed on the preliminary program of a meeting of the Society for which abstracts ready for publication are in the hands of the Secretary.

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program. (A paper presented by two or more authors is assigned to the first named author.) Papers received after the program has been printed will be placed in the supplementary program.

All supplementary papers will be grouped according to subject matter and will be called for at their appropriate sessions only, these sessions to be designated on the program. The presiding officer may assign a reduced time to these papers or may in his discretion call for them to be read by title only.

Except by special vote of the Society, the maximum allowance of time for the presentation of a paper shall be ten minutes. The presiding officer shall enforce this rule.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts will be published in an early number of the *Physical Review*. Authors should send corrections to the Publications Manager, The American Institute of Physics Incorporated, 175 Fifth Avenue, New York, N. Y.

Other meetings for the current season are as follows:

206. June 17–19, 1936. Seattle, Washington.
208. Joint meeting with American Institute of Physics Incorporated. October, 1936. New York City.
209. November 27–28, 1936. Chicago, Illinois.
210. December 28–30, 1936. Annual Meeting. Atlantic City, New Jersey.

W. L. Severinghaus, *Secretary*
Columbia University, New York, N. Y.
June 5, 1936.

CALENDAR

Monday morning, June 22

9:30 o'clock: Bausch and Lomb Hall: Room 109: Papers No. 1–11. See pages 7–9.

9:30 o'clock: Bausch and Lomb Hall: Room 106: Papers No. 12–22. See pages 9–11.

9:30 o'clock: Dewey Hall: Room 206: Papers No. 23–35. See pages 11–13.

11:30 o'clock: Rush Rhees Library: Welles Brown Room: Meeting of the Council.

Monday afternoon, June 22

12:30 o'clock: Todd Union: Luncheon.

2:00 o'clock: Trips to industrial plants.

3:30 o'clock: Todd Union: Lounge: Tea and reception for ladies.

Monday evening, June 22

6:00 o'clock: Todd Union: Joint dinner with the Rochester Section of the Optical Society of America.

8:00 o'clock: University Stadium: Opera "Madame Butterfly." Tickets $1.00.

Tuesday morning, June 23

9:30 o'clock: Strong Auditorium: Lower Lecture Hall: Symposium on "Some Problems in Applied Physics." See page 14.

Tuesday afternoon, June 23

1:00 o'clock: Taylor Instrument Company: Complimentary luncheon and visit to plant.

1:00 o'clock: Place to be announced: Complimentary luncheon for visiting ladies.

2:00 o'clock: Optional visits to other industrial plants.

4:00 o'clock: Swimming party and picnic: Place to be announced.

ADVANCE REGISTRATION CARD

American Physical Society

ROCHESTER MEETING, JUNE 22–23, 1936

Please return this card at once if you expect to attend the meeting.

Name..... (Last name / First name / Other initials)

I plan to go to Rochester by { automobile ☐ / train ☐ }

arriving about { Sunday A.M. / P.M. / Monday A.M. / P.M. }

leaving about { Tuesday A.M. / P.M. / Wednesday A.M. / P.M. }

Please reserve rooms in the dormitory as follows:

☐ single room for man: ☐ single room for woman

☐ 2 adjoining rooms for man and wife

☐ Please reserve.....tickets for dinner @ $1.25.

☐ Please reserve.....tickets for outdoor opera @ $1.00.

Enclosed please find check for $.....

Return this card to:

Department of Physics, University of Rochester, Rochester, N. Y.

PROGRAM

MONDAY MORNING AT 9:30 O'CLOCK

Bausch and Lomb Hall, Room 109

1. Extrapolated Ranges from Number-Distance Curves. ALLEN KING AND W. M. RAYTON, *University of Rochester.* (*Introduced by T. R. Wilkins.*)—To obtain the ranges of alpha-particles from Wilson chamber data, frequently the integrated plot of the number-distance distribution is used. The straight line portion of this graph is extrapolated to the distance axis to obtain the intercept from which one may calculate the mean range by the equation: $R=I-\pi^{\frac{1}{2}}\alpha/2$ in which α is the parameter for the distribution curve. Since, in the distribution curve, one plots the number of tracks with lengths between l_0 and $l_0+\Delta l_0$ against l_0, the question arises: what is the best representation of the area beyond l_0? G. C. Laurence,[1] Kurie,[2] and others plot the number of tracks with lengths greater than l_0 against l_0. On the other hand, Meitner and Freitag,[3] Philipp and Donat,[4] etc. include the number of tracks at l_0 in this sum. Actually, neither method best approximates the area from l_0 to infinity. A better value to plot is $N_0'=(N_r/(N-N_0))\cdot N$ in which N_r is the number of tracks with lengths greater than l_0; N_0 is the number with lengths between l_0 and $l_0+\Delta l$; and N is the total number of tracks observed. This relation has been applied to polonium data obtained by one of us.

[1] G. Laurence, Phil. Mag. (7) **5**, 1027 (1928).
[2] F. Kurie, Phys. Rev. **41**, 701 (1932).
[3] Meitner and Freitag, Zeits. f. Physik **37**, 481 (1926).
[4] Philipp and Donat, Zeits. f. Physik **52**, 759 (1929).

2. The Alpha-Ray Ranges of Uranium Isotopes. W. M. RAYTON AND T. R. WILKINS, *University of Rochester.*—A Wilson chamber has been applied to an investigation of the ranges of the alpha-ray emitting isotopes of uranium. The use of an extremely thin evaporated film of uranium, and a helium-air mixture in the chamber, enabled us completely to resolve the alpha-ray groups corresponding to uraniums I and II. Some evidence for the existence of the suggested alpha-emitting actino-uranium was found. Certain difficulties with the so-called extrapolated number-distance range make it advisable to determine the mean ranges. This has been done in terms of the mean range of polonium alpha-rays,—a substance known to emit a homogeneous group. The values we obtain for the ratio of the mean ranges of U I and U II to that of polonium are 0.6902 $\pm$0.00054 and 0.8356$\pm$0.00063 respectively. These correspond to mean air ranges, at 15°C and 760 mm pressure, of 2.625 cm and 3.179 cm if we use the value 3.805 cm for polonium, as determined by Lewis and Wynn-Williams.[1]

[1] Proc. Roy. Soc. **A136**, 349 (1932).

3. Proportional Counter for Studying Neutron Intensities and Neutron Stimulated Nuclear Disintegrations. ROBLEY D. EVANS AND M. H. KANNER, *Massachusetts Institute of Technology.*—A simple counter for neutrons has been developed by equipping a cylindrical lithium-cathode (2 cm by 12 cm) tube-counter (filled with He at 16 cm Hg) with a large diameter (No. 18 B. & S. Ni) polished wire anode. At voltages of 0 to 70 volts below the gamma-ray threshold of *ca.* 1700 volts the device acts as a proportional amplifier responding to the alpha-ray and probably to the H^3 disintegration products emitted from the wall when neutrons are captured by the lithium cathode. At these voltages it is insensitive to intense gamma-rays from the neutron source. Because of the gain by gas amplification within the counter, a less sensitive amplifier is required than when the usual lithium ionization chamber and linear-amplifier combination is employed. Efficiency and low noise level are retained or enhanced by this simplification of the technique. The present pulse amplifier and recorder is compact, portable, fully a.c. operated and very rugged. Plane-parallel and other electrode forms are being studied to seek greater flexibility and wider applicability. The counter's negligible sensitivity to beta-rays and intense gamma-radiation suggests its use with electrode materials such as C, Mg, Al, P, S, Cr, Zn, and many others for direct observation of alpha-rays or protons produced in nuclear disintegrations by neutrons.

4. Counter Statistics for Chain Disintegrations. L. I. SCHIFF, *Massachusetts Institute of Technology.*—The theory advanced in an earlier paper on the statistical analysis of counter data (in press) is extended to include chain or series disintegrating sources. It is shown that this theory gives the expected number of counts correctly when the Bateman expressions for the relative populations of the different substances in the chain during transient equilibrium are used as the expectation functions of a particle through the counter, provided that the mean lives of all members of the chain are either large or small compared to the resolving time of the counter and circuit. In the intermediate case, where the mean life of one or more of the decaying products is of the order of magnitude of the resolving time, the theory becomes much more complicated. It is developed explicitly for one such intermediate life product in a series, and is capable of further extension. The necessity for and the method of accounting for the relative efficiencies of the various products of disintegration in producing counts are shown.

5. Cosmic-Ray Disintegrations in Light Elements. GORDON L. LOCHER, *Bartol Research Foundation of the Franklin Institute.*—A preliminary report is given of a series of counter-controlled cloud chamber investigations of cosmic-ray bursts in light elements. Elements of low atomic number are used, since their nuclear constitutions and the energies required to produce nuclear transformations in them are better known than are those of heavy ones. The results so far obtained confirm previous work on

bursts in light elements,* in showing that nuclear secondaries are emitted. These nuclear particles usually emanate from the walls of the cloud chamber, but sometimes originate in the gas (argon); comparison of the frequencies of their occurrence in random expansions and expansions controlled by counters in various configurations excludes the possibility that these tracks are merely of radioactive origin. The probability of obtaining a nuclear track on a counter-controlled photograph increases as the configuration of counters is altered to respond to bursts of increasing size. The cloud machine is arranged to expand swiftly, and makes a small stroke, in order to reduce distortion of tracks. A minimum amount of massive material was used in constructing the apparatus, to reduce the number of secondary centers of disintegration in surrounding materials; this is particularly important, since the secondary centers are produced partially, if not wholly, by non-ionizing emissions.

* G. L. Locher, Phys. Rev. **45**, 296A (1934).

6. The Production of Bursts of Cosmic-Ray Ionization from Various Materials. C. G. MONTGOMERY AND D. D. MONTGOMERY, *Bartol Research Foundation of the Franklin Institute.*—Three spherical steel ionization chambers, placed at the corners of a triangle, were connected to the grid of a single vacuum tube electrometer. The chambers had a diameter of three inches, a wall thickness of a millimeter, and were filled with argon to a pressure of 300 pounds per square inch. Bursts of ionization, in the three chambers, from material placed above them, were recorded photographically. The rates of production of bursts greater than 1.6×10^5 ion pairs from small thicknesses of magnesium, iron and lead were measured. The rates of occurrence per atom were found to be approximately proportional to the square of the atomic number of the producer. The effective collision radius for lead was found to be about 2×10^{-13} cm for bursts of the sizes measured when the number of burst-producing rays was taken equal to the number of cosmic rays recorded by Geiger counters.

7. Gamma-Rays of Lithium and Fluorine Under Alpha-Particle Bombardment. KARL C. SPEH, *Yale University.*—The quantum energy of the Γ-rays induced in lithium and fluorine under bombardment by polonium α-particles has been determined, and its variation with the energy of the incident beam has been studied. In the case of lithium no change in energy was observed as the range of the incident α-particles was reduced from 3.9 cm to 2.5 cm. This is taken to support the interpretation of the radiation as due to excitation of the lithium nucleus without capture of the α-particle. At an incident range of 3.9 cm the induced fluorine radiation is shown to consist of two components. When the incident range is reduced to 3.1 cm the harder component disappears. Possible explanations are discussed, and the existence of a hitherto undetected proton group of low energy is suggested.

8. Collisions of Alpha-Particles with Sulphur Nuclei. R. L. ANTHONY, *Yale University.*—More than 700,000 thorium C and C′ alpha-particle tracks have been photographed in a Wilson chamber filled with a mixture of 70 percent hydrogen sulphide and 30 percent hydrogen. The collisions with sulphur nuclei were studied by replacing the film in the camera and projecting. A range velocity curve for recoil sulphur atoms has been constructed by plotting the measured ranges against the calculated velocities for 60 selected forks. This curve is compared with those of other workers in this field. It is shown that the formula of Blackett and Lees, $R=kmz^{-\frac{1}{2}}f(v)$, where R, m, z, and v are the range, mass, atomic number, and velocity of the recoil atom, does not apply, and that this formula should be modified to take into consideration the electronic structure of the atoms for the case of recoil atoms of low energies. No disintegrations of sulphur nuclei were observed. (Maximum reduced air range of alpha-particles in the chamber was 7.8 cm.) The methods of measurement and calculation have been thoroughly checked by applying them to collisions of alpha-particles with protons.

9. Reversible Change of Thermal Energy Accompanying Adiabatic Change of Magnetization in Nickel. T. C. HARDY, *Columbia University.*—The experimental method devised by A. Townsend[1] has been so improved as to permit a study of the magneto-caloric effect in materials for which the total hysteretic energy increase is small in comparison with the reversible thermal energy changes which occur during a half cycle of magnetization. The present specimen of nickel is the same as that used by Miss Townsend, except that it has been annealed at 1100°C for 2 hours in hydrogen at atmospheric pressure and cooled to room temperature in 10 hours. The hysteresis loss per half cycle is approximately 1200 ergs/cm³. As the magnetization is decreased from near saturation to, approximately, the knee of the magnetization curve, the thermal energy decreases almost linearly with magnetizing field by the amount, 9000 ergs/cm³. Below the knee of the curve, the magnetization decreases rapidly to zero and the thermal energy decreases by an additional 16,000 ergs/cm³. On remagnetization the same process is reversed, except for the addition of the hysteresis heat, which appears in the region of most rapid variation of magnetization with field. Throughout the entire process the decrease of thermal energy is several times greater than the external work done by the specimen on the magnetizing currents.

[1] Phys. Rev. **47**, 306 (1935).

10. Coercive Force in Single Crystals of Silicon Ferrite. K. J. SIXTUS, *Research Laboratory, General Electric Company.*—The coercive force H_c of ten single crystal disks of silicon ferrite with different orientation has been measured. The field was applied in various directions in the plane of the disks and H_c determined in these directions using a null method. H_c varied considerably in each disk; in a crystal which had very nearly a (110) plane parallel to the surface it changed between 0.10 and 0.35 oersteds. The direction of maximum and minimum H_c is not determined by those tetragonal ([100] or [010]) axes lying in or nearly in the plane of the disk but by the direction of the [001] axis which is most nearly perpendicular to

that plane. In all samples H_e had a minimum in a direction at right angles to the [001] axis, a maximum in the direction of the projection of the [001] axis upon the plane of the disk. The absolute value of the minimum depends on the direction of the [100] or [010] axis, the value of the maximum on the direction of the [001] axis in a disk. The results are discussed on the basis of Bloch's theory of coercive force.

11. The Magnetic Moment of the Proton. J. M. B. KELLOGG, I. I. RABI, *Columbia University*, AND J. R. ZACHARIAS, *Hunter College of the City of New York.*—We have applied to the measurement of the magnetic moment of the proton the methods which we used for the deuteron as reported at the last Washington meeting. We find the h.f.s. separation for the normal state of the H atom to be 0.0482 cm^{-1} from which we calculate the nuclear moment to be 2.85 ± 0.15 nuclear magnetons as compared with 0.85 ± 0.03 for the deuteron. The ratio of the two moments, 3.35, should be more accurate than the individual moment measurements. Assuming simple additivity in the deuteron the neutron moment is 2 nuclear magnetons.

MONDAY MORNING AT 9:30 O'CLOCK

Bausch and Lomb Hall, Room 106

12. Orientation in Thin Layers of Stearic Acid by Electron Diffraction. K. H. STORKS, *Bell Telephone Laboratories, Inc.* (*Introduced by L. H. Germer.*)—Electron diffraction patterns have been obtained from films of stearic acid, by the reflection method and also by the transmission method. For transmission, films are prepared by evaporation from alcohol solution directly upon a previously prepared foil of "rezoglas." This backing foil is 100A thick and does not contribute appreciably to the diffraction pattern. (Cellulose nitrate films of 300A thickness have also been used.) A single crystal of stearic acid on rezoglas gives a rectangular array of diffraction spots corresponding to the monoclinic alpha-modification. A crystal is always oriented with its (001) plane in the plane of the foil. Transmission patterns have also been obtained from stearic acid deposited upon gold films which had previously been sputtered upon rezoglas. The spot pattern of stearic acid is obtained superposed upon Debye-Scherrer rings of gold. For reflection experiments, stearic acid layers have been formed upon polished nickel by evaporation, and upon other materials. At glancing incidence an electron beam strikes many crystals. Diffraction patterns consist of diffuse spots forming broad bands inclined 33° to the surface plane. This must be the inclination of long hydrocarbon chains to the surface normal. Separations of these bands correspond to 2.5A spacing between carbon atoms.

13. An Effective Method for Using Low-Melting Metals for X-Ray Tube Targets. T. R. FOLSOM, *New York Memorial Hospital.*—Experiments were conducted to develop a more economical target for a 600,000-volt c.p. x-ray machine. A target which was found to be very practical consists of a very thin, stretched disk of copper, upon which lead is plated to 1/100 of an inch. Two years of experience has shown that it will stand up under 10 ma electron bombardment at 600,000 volts under constant use. This method seems applicable for experimental cases, where a low-melting point metal is desired as a target.

14. An Illumination Meter for Photographic Laboratory Work. AGNES TOWNSEND, *Barnard College.*—A simple type of photometer is described and its application in the teaching and practice of photography is discussed. The instrument employs as a standard a 2.2-volt lamp operated from dry cells and a neutral photographic wedge for making the comparison. Measurements can be made with sufficient accuracy for many purposes with illuminations as low as 0.01 meter candles. The photometer can be used to determine the illumination on the ground glass of a camera or on the easel of an enlarger where a measurement of the maximum and minimum illuminations is sufficient to specify the range required of the photographic emulsion and the exposure needed. The meter can be used also to obtain exposure *versus* density curves for photographic films and papers.

15. The Polarimetric Determination of Optical Properties. RICHARD MAURY EMBERSON, *University of Missouri.* (*Introduced by H. M. Reese.*)—A study has been made of the polarimetric method of determining the optical properties of a surface. The experimental work was done with a polarimeter, which was designed and constructed in the university shops. The equations used in the computation of results were based on the theoretical work of Dr. Thornton C. Fry. It was found that certain instrumental errors profoundly affected the results. When the observed data were freed of these errors, a decrease was noted in the variation of the computed optical constants of a surface with the angle of incidence at which the data were obtained. Studies were made of thin metallic films deposited on glass. The results indicated that, while the computed film thicknesses were of the correct order of magnitude, they were not independent of the angle of incidence of observation. Also, the computed thicknesses were always complex, with the imaginary part negative and about the same size as the real part.

16. Angular Momentum in Certain Optical Problems. F. T. HOLMES, *University of Virginia.*—Fresnel showed that ordinary plane polarized light is split into two beams of equal intensity, which are circularly polarized in opposite senses, by passage through his compound prism. The experiment has been performed using plane polarized

Zeeman s components. The result is that, in accordance with what one would expect classically, each of the s component beams is split into two beams by the Fresnel compound prism. Thus, before the spectroscopic analysis, the high and low frequency s components were indistinguishable within the limits of observation. This inability to distinguish between positively and negatively polarized linear photons may be common to all optical systems. By assuming one-to-one correspondence between ellipticity, observable angular momentum, and the angle between direction of propagation and the angular momentum vector, it follows from our experimental knowledge that: (1) The observable angular momentum of a beam of photons (of each photon?) in a homogeneous isotropic field-free medium is vectorially constant in time; (2) In general, an optical measurement, by ordinary methods, of ellipticity or of angular momentum produces a vectorial change in the angular momentum of the beam of photons (of each photon?) on which the observation was made.

17. Reflecting Power of Evaporated Metal Films in the Near and Far Ultraviolet. G. B. SABINE, *Cornell University.*—The reflecting power of evaporated metal films from the visible to 450A has been determined for the following elements: Aluminum, antimony, beryllium, bismuth, cadmium, chromium, copper, gold, iron, lead, magnesium, manganese, molybdenum, nickel, palladium, platinum, silver, tellurium, tin, titanium, zinc, and zirconium. Photographic methods were used. From the visible to 2400A, a quartz mercury arc with calibrated wire screens and a prism spectrograph were employed. From 2400A to 450A it was necessary to use a vacuum spectrograph with grating, a discharge tube and oiled photographic film, observing the precautions for their employment outlined by Harrison and Leighton.[1] The accuracy of the work in the near ultraviolet is of the order of three percent and in the far ultraviolet not better than five percent. Curves of reflecting power against wave-length for these metals will be shown.

[1] J. Opt. Soc. Am. **20**, 313 (1930).

18. Mean Lives of Potassium Doublets λ4047–4 and λ3447–6. DAVID SINCLAIR AND HAROLD W. WEBB, *Columbia University.*—The mean lives of the potassium doublets λ4047–4 and λ3447–6 were measured by the alternating voltage method previously described.* The radiation was excited in a sealed-off Pyrex tube by low voltage electrons from a hot cathode. A sodium hydride vacuum photoelectric cell was used as the detecting system. Optical filters were used to isolate the two doublets which were treated as a single line. The mean life of λ4047–4 was found to be 3.79×10^{-7} sec., the mean life of λ3447–6 to be 8.50×10^{-7} sec., with an estimated precision of one percent. The results were obtained on the assumption that the radiation decays exponentially after excitation. The correctness of this and other assumptions was demonstrated by means of a low frequency excitation voltage of distorted wave form which simulated the conditions at high frequency. The mean lives were found to be the same for vapor pressures ranging from 4×10^{-5} mm to 10^{-2} mm. This can be accounted for by the assumption that only 10 percent of the absorbed λ4047–4 and λ3447–6 is re-emitted at these wave-lengths. Absorption measurements were found to be consistent with this assumption.

* H. W. Webb, Phys. Rev. **24**, 113 (1924); F. G. Slack, Phys. Rev. **28**, 1 (1926); P. H. Garrett, Phys. Rev. **40**, 779 (1932).

19. Hyperfine Structure and Wave-Length of the Infrared HgI 6^1P-7^1S Line. M. H. M. HUNT AND J. S. CAMPBELL, *Institute of Applied Optics, University of Rochester.*—The hyperfine structure of the mercury arc line 10,140 produced in an air-cooled Cooper-Hewitt tube has been photographed with a Fabry-Perot interferometer at mirror separations ranging from 12 to 60 mm. The nine expected components give six completely resolved groups in a pattern of total width, 226 $cm^{-1}\times10^{-3}$. The total magnetic separations of isotopes 199 and 201 in 6^1P_1 are 179 and 161, respectively, in fair agreement with the values 181 and 165 obtained by Schüler and Keyston from 6^1P-7^1S.[1] The principal components due to isotopes 200, 202 are resolved showing a relative shift of 15, while the less directly obtained 199–201 shift is somewhat smaller than this. Since the average shift in 7^1S obtained by Schüler from 6234 is about 30, it follows that 6^1P has a shift of approximately 15 between consecutive even isotope levels. An interferometric determination of the wave-length of the sharpest component will be discussed in connection with the mean wave-length to be used for the line when unresolved.

[1] Zeits. f. Physik **72**, 423 (1931).

20. On the Spectrum of Ce IV. R. J. LANG, *University of Alberta, Edmonton, Canada.*—Further progress has been made in the analysis of this spectrum. Some twenty energy levels have been found, including two members of the F series which are of interest because of their bearing on the structure of the rare earths.

21. The Pure Rotation Spectrum of Water Vapor. H. M. RANDALL, N. GINSBURG, D. M. DENNISON, AND R. L. WEBBER, *University of Michigan.*—These measurements begun in 1934 include 139 lines within the spectral region between 18 and 75 mμ. The highest resolution yet applied by gratings in this part of the spectrum has been employed with the result that the lines are very narrow and well separated. In fact quite complete resolution is possible for lines as near together as 0.6 cm^{-1}, while lines considerably closer are readily shown to be double or triple. This has been accomplished by the use of gratings having 1200 and 900 lines per inch and slit widths of a millimeter or less. For lines of the longest wave-lengths the gratings had 360 lines per inch and the slit widths varied from 1 mm to 1.4 mm. The results give promise of yielding very satisfactorily to analysis. Already somewhat more than one-third of these lines together with the longest of the measurements obtained by Wright and Randall have been classified. Energy levels have been obtained up to and including $J=6$ and some for $J=7$. For these higher levels, it has been found that the stretching of the molecule due to centrifugal force gives rise to a very large change from the calculated levels of the order of magnitude of 100 cm^{-1}.

22. Pressure Effect in the HCN Bands in the Near Infrared. S. D. CORNELL AND WILLIAM W. WATSON, *Yale University.*—According to Herzberg and Spinks[1] the lines of the HCN absorption band at 1.04μ are considerably more broadened by increase in HCN gas pressure than are the lines of the HCl overtone bands with increase in HCl pressure. They also reported the broadening to decrease with increasing molecular rotation. Quantitative measurements of line-widths in the 1.04μ band at different HCN pressures, however, indicate no dependence on J. The half-widths increase linearly with pressure, the change being 0.55 cm^{-1} per atmosphere. This value is actually slightly less than that observed by H. Becker for the first harmonic band of HCl. These results indicate that dispersion forces are the predominant broadening influence, in agreement with the predictions of theory similar to that of H. Margenau[2] for broadening by foreign gases. The observed pressure broadening gives no evidence for molecular association.

[1] Herzberg and Spinks, Proc. Roy. Soc. **A147**, 434 (1934).
[2] H. Margenau, Phys. Rev. **49**, 596 (1936).

MONDAY MORNING AT 9:30 O'CLOCK

Dewey Hall, Room 206

Papers No. 23 and 35 will be read by title.

23. The Electrical Charge of Mammalian Red Blood Cells Under Normal Conditions and in the Anemias. LAURENCE S. MOYER AND HAROLD A. ABRAMSON, *Biological Laboratory, Cold Spring Harbor, Long Island.*—From the data on the surface area and electrical mobilities of red blood cells in a given solution under approximately physiological conditions, the net surface charge per cell as well as the charge per unit area can be calculated by means of the modern theory of electrolytes. The lowest value of the net charge density in the series investigated was 1890 electrostatic units in the rabbit. Man and the rhesus monkey were the same, both having approximately 4500 electrostatic units of net charge per square centimeter. Amongst the mammals investigated, given here in the order of increasing charge density, were: rabbit, sloth, pig, opossum, guinea pig, man, rhesus monkey, cat, mouse, rat, dog; the dog had the highest charge density of 5600 electrostatic units. This order is completely changed if the effective number of electrons at the surface of the cell, rather than the charge density, is calculated because this depends upon the size of the cell. Man, among the animals studied, had the highest number of effective electrons at the surface, the value being equal to 15 million electrons. In cases of anemia in human beings, the abnormal cells apparently possess a mechanism which is capable of keeping the surface density of net charge constant even though comparatively large changes in surface area may occur.

24. Absolute Photoelectric Yield of Beryllium, Magnesium, and Sodium. MARVIN M. MANN AND LEE A. DUBRIDGE, *University of Rochester.*—Measurements of the photoelectric yield of these metals have been obtained for wave-lengths ranging from the threshold down to 2400A. Values of α, the probability that an electron at the surface of the metal will absorb a quantum and appear outside as a photoelectron, have been calculated for each surface from the vertical shift of the curves plotted by the Fowler method. Comparison of these values with those computed from simple theoretical considerations, assuming all the light to be absorbed by those electrons in the image field, shows that the theoretical values are greater than experimental values by a factor of approximately 100. Preliminary measurements on slightly contaminated surfaces indicate that α may vary by no more than a factor of 2 or 3 for a given metal. For different metals α may vary by as much as 100 times. The discrepancy between theoretical and observed values of α may be explained by the fact that those electrons in the image field of the surface absorb only a small portion of light incident on the surface. The value of the photoelectric work function of Beryllium obtained by the Fowler method is 3.92 volts.

25. Normal Energy Distribution of Photoelectrons from Potassium Films as a Function of Temperature. C. L. HENSHAW, *Yale University.*—Using a parallel plate condenser the photoelectric normal energy distribution of thin potassium films on silver and platinum has been studied as a function of temperature for films of different thicknesses produced by the molecular ray method. Contact potential was determined by the Kelvin method to a precision of less than 0.02 volt. The results were analyzed by DuBridge's method[1] of fitting the Fowler universal curve. Some irreversible changes in the character of the surface occur such as contact potential or saturation current, but after these are eliminated there are certain deviations from the Fowler curve at the low current end which are reversible with temperature. Adequate shifts for frequency and temperature can still be obtained. The deviations seem to be affected by the temperature at which the film was originally produced. Brady[2] has found no deviations of the *total* energy distribution of potassium films on silver, hence the present observations are probably best explained by changes in the direction of emission of the photoelectrons. With optimum geometrical conditions of the apparatus satisfactory agreement with the Fowler curve was found practically to saturation current for films which were not too thin. This suggests that, to the accuracy of the logarithmic plot, previously found deviations above 50 percent saturation can be attributed mainly to imperfect geometry rather than to transmission coefficients.

[1] L. A. DuBridge, Phys. Rev. **43**, 727 (1933).
[2] J. J. Brady, Phys. Rev. **46**, 768 (1934).

26. Field Currents and Thermionic Currents from Thoriated Tungsten and Pure Tungsten. A. J. AHEARN, *Bell Telephone Laboratories, Inc.*—When the electric field applied to a cold thoriated tungsten filament is raised to a sufficiently high value, 1 to 2×10^6 volts/cm, breakdown occurs, i.e., suddenly the field current discontinuously increases by an enormous amount. This breakdown raises the field current curve to higher currents by about one million-fold. After such a breakdown has occurred, the thermionic activity of the filament is increased. However, when the filament is thoriated and dethoriated by the usual thermal treatment, the field current remains unchanged to within 15 percent. Low temperature treatments (about 1300°K) after but not before breakdown further increase the field currents. High temperature treatments (about 2600°K) erase the effects produced by the breakdown. Similar experiments with pure tungsten show the same phenomena with the following exceptions: (1) Breakdown produces no change in the thermionic emission. (2) Low temperature treatments do not further increase the field current after breakdown. These experiments indicate: (1) The increase in field current following breakdown is due to an increase in the applied field over small local areas. (2) There is sufficient local heating at breakdown to partially thoriate the filament. (3) In thoriation by thermal treatment, the points emitting field currents probably do not become thoriated.

27. Influence of Crystal Structure on Electron Emission from "218" Tungsten Wire. W. B. NOTTINGHAM, *Massachusetts Institute of Technology.*—The thermionic emission from 218 tungsten wire has been shown by Johnson and Shockley[1] to vary with crystallographic direction. Single crystals of this wire average 0.25 to 1.0 cm in length and present six strips of strong emission separated by six strips of weak emission as one explores around the filament circumference. The electron energy distribution as indicated by retarding potential measurements becomes ambiguous near "zero field" because the currents received are coming in effect from a cathode of inhomogeneous surface structure to a single collector. In the case of thoriated filaments it is thought that the actual surface exposed may be much more uniform than that found in 218 wire, thus accounting for the accurate reproducibility of the energy distribution curves. In contrast the curves observed with different samples of 218 wire have not been in exact agreement with each other and have generally shown an apparent reflection effect larger than that for thoriated tungsten. If we assume that the work function varies sinusoidally from a minimum to a maximum differing by 0.5 volt, an approximate theory gives good agreement with experiment.

[1] Phys. Rev. **49**, 436 (1936).

28. Cathode Drop in Low Pressure Discharge Tubes. T. J. KILLIAN AND R. S. PRESCOTT, *Barkon Tube Lighting Corporation, Seattle, Washington.*—The cathode drop of aluminum electrodes in low pressure high voltage gaseous discharge lamps containing carbon dioxide was studied as a function of current density and pressure for various shapes. The cathode drop of a plane disk was found to follow the Aston formula $V=A+B(I/a)^{\frac{1}{2}}/p$; where V is in volts, A and B are constants, I/a is the current density, and p is the pressure. With a cylindrical cup the relation was of the form $V=A_1+BI^k$; and was found to be practically independent of pressure in the region from 0.1 to 0.3 mm; and k was found to be in the order of 0.15. An electrode consisting of a capped cylindrical cup with a small hole pierced in the cap approximately followed the relation $V=(A_2/p)\epsilon^{-b(1/p)^c}\times(1-\epsilon^{-k_2I})+V_0\epsilon^{-k_1I}$. The study was made in the region between 0.05 and 0.5 mm of mercury. At 0.1 mm and 5 ma/sq. inch the voltage drop was 1700 for the disk, 550 for the cup, and 400 for the capped cup. Various mechanisms which may account for this large change in the cathode drop are discussed.

29. The Surface Tension of Water from the Velocity of Capillary Waves. V. E. EATON, *Wesleyan University.*—A ripple tank, originally designed for undergraduate instruction, has been described.[1] The following modifications have made it an instrument of precision. The waves were recorded on photographic plates and measured with a comparator. During the exposure of the plate, a method of spark recording was used to determine the frequency of the a.c. to a few thousandths of a cycle. Nine determinations of the surface tension of water gave 72.64 ± 0.03. Within the limits of experimental error the results for tap water are the same as for distilled water. The merits of this method for absolute and for comparative measurements are considered.

[1] Am. Phys. Teacher **4**, 49 (1936).

30. Energy Bands in Metallic Tungsten. MILLARD F. MANNING AND MARVIN CHODOROW, *Massachusetts Institute of Technology.*—The Wigner-Seitz-Slater cellular method as applied to the body-centered lattice has been extended to include boundary conditions for next-nearest as well as nearest neighbors. The wave-functions used are:

$$Ug=As+Bd\frac{xy}{r^2}+Cd\frac{xz}{r^2}+Dd\frac{yz}{r^2}+Ed\frac{y^2-z^2}{r^2}+Fd\frac{3x^2-r^2}{r^2}+Gg\frac{5(x^4+y^4+z^4)-3r^4}{r^4},$$

$$Uu=Hp\frac{x}{r}+Ip\frac{y}{r}+Jp\frac{z}{r}+Kf\frac{xyz}{r^3}+Lf\frac{x(5x^2-3r^2)}{r^3}+Mf\frac{y(5y^2-3r^2)}{r^3}+Nf\frac{z(5z^2-3r^2)}{r^3}.$$

Since all of the d functions are included, the method is now applicable to transition elements. To determine the relation between E and k for a general direction of propagation, it is necessary to solve a fourteenth-order determinant. For special directions of propagation a proper grouping of function breaks the determinant up into lower order determinants which can be handled. For applications to tungsten, the necessary values of the wave functions and their derivatives at the two required radii have been found by the differential analyzer, using an atomic field modified to correct for the renormalization of the valence electrons. The bands that contain electrons under ordinary conditions

are: three beginning at $d_1'=0$, two at $d_2'=0$, and one at $3s_1'g_2'+2s_2'g_1'$. The concentration of electrons near the bottom of the d band accounts for the high binding energy.

31. On the Elastic Constants of an Anisotropic Solid. MILTON S. PLESSET AND RICHARD F. BAKER, *University of Rochester.*—In the most general case of an anisotropic body there are 36 elastic constants which are reduced in number by two classes of relationships. The first class, Green's relations, are usually derived from the potential energy as a quadratic function of the strains but also follow from symmetry considerations of the elastic constant tensor. The second class, Cauchy's relations, are usually based on microscopic considerations of the structure of the body, but in the present paper they are derived in a very simple way by forming three divergence functions of the stress tensor (equilibrium functions). This simple, macroscopic derivation of Cauchy's relations affords a direct way of discussing the necessary conditions for their applicability. In connection with the consideration of the elastic constants of an anisotropic body it is of interest to note that Murnaghan has given an analysis[1] of the energy of deformation of an elastic body with the following result: the assumption that the potential energy is a function of the strains alone is consistent only for an isotropic body. In the present discussion this conclusion is shown to be invalid.

[1] Murnaghan, Proc. Nat. Acad. Sci. **14**, 889 (1928).

32. Nuclear Calculation. D. R. INGLIS, *University of Pittsburgh.*—A method of calculating nuclear properties, which includes the necessary complexity and yet retains some of the analytic simplicity of single-particle representations, consists in applying perturbation theory to the representation in which protons and neutrons have the wave functions of three-dimensional harmonic oscillators in a Cartesian coordinate system. The width of the wave functions is varied for minimum energy, as in the first-order calculation of Heisenberg. To approximate the K.E. correctly, the Hamiltonian operator is expressed in another coordinate system in which the center of gravity is at rest. In making a preliminary comparison of the accuracy of this and other methods, only the proton-neutron Majorana-type interaction $ae^{-b^2r^2}P$ is used. The values of a (unit $mc^2/1000$), determined for values of b from the energy of He^4 by various methods, are here tabulated:

b (unit mc^2/e^2)	1.5	2.0	2.5
Heisenberg	75	115	160
Wigner	58	90	130
Feenberg: Variation	51	82	119
Equiv. 2-body	57	84	118
This method	57	85	120
(Deuteron	51	81	122)

The convergence is rapid: The K.E. correction is greater than the second-order contribution, and contributions of quadruply excited states and of third order are almost negligible in the results given. The method is applicable to other problems, more particles and more interactions.

33. On the Electronic Structure of LiF and LiH. DOUGLAS H. EWING AND FREDERICK SEITZ, *University of Rochester.*—A solution of Hartree's equations for LiF and LiH has been concluded and from this the band structure of the electronic states has been determined using the representation theory of groups. If each atom is surrounded by a cube it is found that the total charge within these is zero for both Li and F in LiF, while in LiH, the H cube contains about 1.3 of the two valence electrons. The first result is to be modified, without question, by the Fock terms in such a direction as partly to ionize the Li cube, and a similar correction will occur in the second case.

34. The Connection Between the Kepler Problem and the Four-Dimensional Rotation Group. OTTO LAPORTE, *University of Michigan.*—In recent researches by Fock, Hulthén, and Bargmann[1] attention has been called to this connection in various ways. A simple and extremely elementary way of treating the hydrogen problem is in momentum space (Pauling-Podolsky and Hylleras), using formulae for stereographic parameters recently developed by G. Y. Rainich and the author.[2] The wave function is seen to be a 4-dimensional hyperspherical surface harmonic divided by $(1+\xi_\rho\xi_\rho)^2$ where $\xi_i=p_i(-2mE)^{-1/2}$. The infinitesimal operators admitted by the differential equation which this function satisfies are, besides rotations (angular momentum integrals), the operators

$$\tfrac{1}{2}(1-\xi_\rho\xi_\rho)\partial/\partial\xi_i+\xi_i\xi_\rho\partial/\partial\xi_\rho+2\xi_i$$

which are identical with Runge's vector integral. It is possible in this way to obtain all eigenfunctions by differentiation in analogy with Maxwell's method of obtaining 3-dimensional solid harmonics. The evaluation of matrix elements involving radial eigenfunctions becomes simpler in momentum space using a generalization to four dimensions of Kramers' "$\xi-\eta$ method." By means of the finite transformation of the above operator a "displaced" solution is constructed which may serve as Green function or as generating function.

[1] Fock, Hulthén and Bargmann, Zeits. f. Physik, vols. 86, 98, 99.
[2] Rainich and Laporte, Trans. Am. Math. Soc. (1936).

35. The One-Dimensional Problem in the New Relativity. D. G. BOURGIN, *University of Illinois.*—A solution has been found for the one-dimensional problem of the Page-Milne relativity theories. That is to say, the motions have been determined consistent with the physically necessary postulate that equivalence of each of two observers to a third implies equivalence of all observers. The method used is that of the Lie theory of groups. With the aid of one new theorem in this discipline it is proved that $(dx^2-c^2dt^2)/F(ct-x)F(ct+x)$ is invariant. A three-parameter group generates the motions. In general the Lorentz transformations do not form a subgroup. Even when they do $[F(\ )=(\ )^n]$ it does not follow that the compound of a Lorentz transformation and one characteristic of the particular motion considered is permissible, for the two may not form a group. Page's constant acceleration case corresponds to $F(\ )=(\ )^2$. The Einstein-Lorentz velocity addition formula holds formally for the general motion though the velocities are now variable functions of distance and time.

TUESDAY MORNING AT 9:30 O'CLOCK

Strong Auditorium, Lower Lecture Hall

SYMPOSIUM

ON

SOME PROBLEMS IN APPLIED PHYSICS

F. K. Richtmyer, presiding

Invited Papers

1. **Applied Physics in Photography.** C. E. K. MEES, *Eastman Kodak Company.* (30 minutes)
2. **Some Properties of Adsorbed Films on Composite Surfaces.** IRVING LANGMUIR, *General Electric Company.* (30 minutes)
3. **Physics in Optical Instrument Manufacture.** W. B. RAYTON, *Bausch and Lomb Optical Company.* (30 minutes)
4. **Some Applications of the Electron Theory of Solids.** FREDERICK SEITZ, *University of Rochester.* (30 minutes)

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member one only of these will be assigned a place on the regular program while the others will be placed in a supplementary program to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for only at the session indicated.